## **CLAIMS**

What is claimed is:

- 1. An apparatus, comprising:
- an integrated circuit (IC) die including a substrate formed with a first semiconductor material;
- a cooling device formed with a second semiconductor material and directly bonded to the substrate of the IC die; and
- the cooling device having embedded therein a plurality of interconnected liquidconducting passages.
- 2. The apparatus according to claim 1, wherein the first and the second semiconductor materials are silicon.
- 3. The apparatus according to claim 2, wherein the cooling device further includes a liquid inlet fluidly coupled to the plurality of liquid-conducting passages and a liquid outlet fluidly coupled to the plurality of liquid-conducting passages.
- 4. The apparatus according to claim 3, wherein the cooling device further includes a cooling plate having a first and a second cooling plate side with a plurality of interconnected channels being formed in the first cooling plate side; and an enclosing plate mounted to the first cooling plate side to enclose the plurality of interconnected channels and to form the plurality of liquid-conducting passages.
- 5. The apparatus according to claim 4, wherein the enclosing plate comprises the substrate of the IC die; the first cooling plate side is directly mounted to the substrate of the IC die by a silicon-to-silicon bond; and the liquid inlet and liquid outlet are formed in the cooling plate and extend between the plurality of interconnected channels and the second cooling plate side.

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- 6. The apparatus according to claim 4, wherein the enclosing plate comprises a cover plate; and the second cooling plate side of the cooling plate is directly bonded to the substrate of the IC die by a first silicon-to-silicon bond.
- 7. The apparatus according to claim 6, wherein the first cover plate side is attached to the first cooling plate side to form the liquid-conducting passages; and the liquid inlet and the liquid outlet are formed in the cover plate and extend from the first cover plate side to the second cover plate side.
- 8. The apparatus according to claim 7, wherein the cover plate is formed of silicon; and the first cooling plate side is directly bonded to the first cover plate side by a second silicon-to-silicon bond.
- 9. The apparatus according to claim 4, wherein the cooling plate is formed of polycrystalline silicon fabricated from cast polycrystalline ingots.
- 10. The apparatus according to claim 4, further comprising:
  - a pump;
  - a liquid feed tube fluidly coupled between the pump and the liquid inlet; and
  - a liquid exit tube fluidly coupled between the liquid outlet and the pump.
- 11. The apparatus according to claim 10, wherein the plurality of interconnected channels forms a channel network; and the channel network includes one pair of opposed channel segments and a plurality of parallel channel segments fluidly coupled between the opposed channel segments.
- 12. The apparatus according to claim 11, wherein the liquid inlet and liquid outlet are fluidly coupled at a pair of diametrically-opposed corners of the channel network.
- 13. A method comprising:
  - providing an enclosing plate made of a first semiconductor material and a

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cooling plate made of a second semiconductor material, the cooling plate having a first cooling plate side and a second cooling plate side;

- machining a plurality of interconnected channels into the first cooling plate side of the cooling plate; and
- heating the cooling plate to form a first semiconductor-to-semiconductor bond between the first cooling plate side and the enclosing plate to enclose the interconnected channels and to form a plurality of liquid-conducting passages.
- 14. The method of claim 13, wherein the first semiconductor material and the second semiconductor material are silicon.
- 15. The method of claim 14, wherein the enclosing plate is an integrated circuit (IC) die.
- 16. The method according to claim 15, further comprising:
- drilling a pair of liquid flow holes into the second cooling plate side to intersect with the interconnected channels so as to form a liquid inlet and a liquid outlet.
- 17. The method according to claim 16, further comprising:
- providing a pump and fluidly connecting the pump between the liquid inlet and the liquid outlet to form a closed loop circulation path for a cooling liquid.
- 18. The method according to claim 17, further comprising:
- sizing the width and length of the cooling plate to be substantially the same as the IC die.
- 19. The method according to claim 14, wherein the enclosing plate is a silicon cover plate and the method further comprises:
  - providing an IC die;
- the heating of the cooling plate further includes forming a second silicon-tosilicon bond between the second cooling plate side and the IC die.

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- 20. The method according to claim 19, further comprising:
- drilling a pair of liquid flow holes through the cover plate to intersect with the interconnected channels in the cooling plate to form a liquid inlet and a liquid outlet.
- 21. The method according to claim 20, further comprising:
- fluidly connecting a pump between the liquid inlet and liquid outlet to form a closed loop circulation path for a cooling liquid.
- 22. The method according to claim 21, further comprising:
- sizing a width and a length dimension of both the cooling plate and the cover plate to be substantially the same as a width and a length dimension of the IC die.

## 23. A system, comprising:

- an electronic assembly including an integrated circuit (IC) die having a substrate formed with a first semiconductor material; the electronic assembly further including a cooling device formed with a second semiconductor material and directly bonded to the substrate of the IC die; and the cooling device including a plurality of enclosed, interconnected liquid-conducting passages and a liquid inlet and a liquid outlet which are fluidly coupled to the plurality of liquid-conducting passages;
  - an IC package having the electronic assembly mounted therein;
  - a printed circuit board (PCB) having the IC package mounted thereon;
  - a dynamic random access memory mounted on the PCB and electrically coupled to the electronic assembly; and
  - an input/output interface mounted on the PCB and electrically coupled to the electronic assembly.
- 24. The system according to claim 23, wherein the IC die is a microprocessor; the PCB is a motherboard; and the input/output interface is a networking interface.
- 25. The system according to claim 23, wherein the first and the second semiconductor materials are silicon.

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26. The system according to claim 25, wherein the cooling device includes a cooling plate having a first and a second cooling plate side with a plurality of interconnected channels being formed on the first cooling plate side; and an enclosing plate mounted to the first cooling plate side to enclose the plurality of interconnected channels and to form the plurality of liquid-conducting passages.

- 27. The system according to claim 26, wherein the enclosing plate comprises the substrate of the IC die; the first cooling plate side is directly bonded to the substrate of the IC die by a silicon-to-silicon bond; and the liquid inlet and liquid outlets are formed in the cooling plate and extend between the plurality of interconnected channels and the second cooling plate side.
- 28. The system according to claim 25, wherein the enclosing plate comprises a cover plate; and the second cooling plate side of the cooling plate is directly bonded to the substrate of the IC die by a first silicon-to-silicon bond.
- 29. The system according to claim 28, wherein the cover plate has a first cover plate side and a second cover plate side; the first cover plate side is attached to the first cooling plate side to form the liquid-conducting passages; and the liquid inlet and the liquid outlet are formed in the cover plate and extend from the first cover plate side to the second cover plate side.
- 30. The system according to claim 28, wherein the cover plate is formed of silicon; and the first cooling plate side is directly bonded to the first cover plate side by a second silicon-to-silicon bond.